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Patent proprietor: **Offringa Dirk Dooitze ; Dutch Trading Center Tiel B.V.**

5 **Method and device for cooling air**

This invention concerns a method and a device for cooling air.

More in particular, it concerns a method with which an efficient cooling can be realized.

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To this end, the invention concerns a method for cooling air, characterized in that this cooling is at least realized by directing the air to cool through first channels of a heat exchanger, while in second channels of this heat exchanger an evaporation is realized by wetting the walls of these second channels and in combination therewith directing an airflow through the second

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channels. Preferably, at least part of the second airflow is cooled before bringing this airflow into the second channels. In this way, the second airflow can take up more moisture in itself, such that a larger cooling capacity becomes possible.

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In practice, it is preferred that the second airflow is at least partially cooled by branching off this flow from the first airflow.

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According to a particular embodiment, use is made of a second airflow consisting of two or more partial flows that are supplied to the second channels at different locations. In this way it is prohibited that the air in the second channels exhibit too quickly a too high humidity and hence, that few additional moisture is absorbed for realizing the evaporation. By intermediately producing fresh air in the second channels, a better evaporation effect is obtained.

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According to a practical embodiment several partial flows are systematically at different locations branched off from the first channels.

Further it is also preferred that the second airflow in essence is running parallel to the first one in counter current, such that the second airflow may be branched off easier from the second one.

- 5 According to a particular embodiment, for the second airflow use is made of at least two partial flows that are preferably separated from each other, respectively a first partial flow, which is branched off before or near the inlet of first channels and which realizes a cooling effect in the first part of the first channels, and a second partial flow, which may also consist in itself of several partial flows, which second partial flow is branched off from the second
10 part of the first channels and/or at the exit thereof and which is used to create a cooling effect in the second part of the first channels. This enables to pursue an optimal cooling, such that in the first channels a cooling up to the wet-bulb temperature is aimed for, while in the second part a dewpoint cooling takes place.
- 15 According to another particular feature of the invention, the cooling is implemented in a plate heat exchanger and at least part of the second airflow from the first channels is branched off via direct connections between the compartments that are formed between the plates, and this by means of passages in the plates and/or a mutual space locally at the edge of the plates that are overlooked by both compartments. As a result, the air cooled in the first channels is fed
20 directly into the second channels, such that a heating of the second airflow, before it is fed into the second channels, is excluded. Moreover, the use of two different collectors at least at one side of the plate heat exchanger is excluded.

- Another improvement of the invention consist of the fact that said cooling by means of said
25 heat exchanger is combined with a so-called mechanical cooling, more in particular a compression cooling, and preferentially this mechanical cooling is controlled as a function of external parameters. By using the correct control, not only the temperature of the air, but also the humidity can be kept at the desired value, without conducting a special intervention to adjust the humidity. After all, said two coolings complete each other.

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Preferably, the compression cooling is switch on to a larger extent as the humidity of the inlet air increases. After all, when the humidity increases, the efficiency of the cooling in the heat exchanger decreases and this can ideally be compensated by putting the mechanical cooling into operation. When the air humidity becomes too low, said heat exchanger, which makes

use of a dewpoint cooling, pays off optimally and the mechanical cooling may be limited or excluded, which further has as the advantage that the supplied air is not dehumidified unnecessarily in the mechanical cooling and hence, automatically, too dry air is excluded.

- 5 Preferably, use is made of several compressors, preferably with a different nominal power, such that one or more of these compressors can be respectively switched on or switched off, as a larger or smaller compression cooling is desired.

10 More preferably, one or more compressors with an adjustable power are to be used, preferably by means of a frequency controller.

By means of the techniques as described above the power of the mechanical cooling can systematically be adjusted as a function of the need thereof.

- 15 The invention further concerns a device for the embodiment of said method, characterized in that it consists at least of a heat exchanger with first channels for the air to cool and second channels ; means to wet the walls of the second channels; and means to direct the air to cool through the first channels, as well as to direct an airflow through the second channels.
- 20 Specific details of preferred embodiments of this invention are described in the dependent claims, and are also described in the subsequent detailed description.

25 With the aim to better show the features of the invention, some preferred embodiments of a device according to the invention are described by way of example without any delimiting character, with reference to the accompanying drawings, in which :

Figure 1 schematically shows the device according to the invention ;

Figure 2 schematically shows a more practical structure of the device according to

Figure 1;

30 Figures 3 to 8 schematically show different versions of the device according to the invention ;

Figures 9 to 14 a number of special details show that can be applied in the device according to the invention.

As is schematically depicted in Figure 1, the device 1 according to the invention consists at least of a heat exchanger 2 with first channels 3 and second channels 4 ; means 5 to wet the walls 6 of the second channels 4 ; and not shown means to direct the air to cool in the form of a first airflow 7 through the first channels 3, as well as to direct a second airflow 8 through the second channels 4.

In the example shown the second airflow 8 is branched off from the second airflow 7, after which the latter has left the heat exchanger 2.

10 The means 5 to wet the walls 6 may be of arbitrary nature, but preferably contain – as indicated in Figure 1 - a supply 9 for a liquid, more in particular water, that is distributed over the walls 6 by means of a nebulizer or the like. As also depicted, these means 5 comprise preferably, but not necessarily, an absorbent layer 10, applied onto the walls 6, to distribute the moisture.

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The action of this device 1 relies on the fact that the moisture on the walls 6 is being evaporated and transported by means of the second airflow 8. Because of this, the walls 6 are cooled down, which also brings about a cooling effect in the first channels 3, such that the airflow 7 is cooled down. Because the airflow 8 is branched off from the airflow 7, it is relatively cold and therefore can absorb an optimal amount of moisture.

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As is depicted in Figure 2, preferably use is made of a plate heat exchanger, to obtain an optimal heat exchange, such that the first channels 3 are formed by the compartments 11 and the second channels 4 are formed by the compartments 12. The aforementioned layer 10 is hereby applied on the outside of the wall of the compartments 11.

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As depicted in Figure 2, preferably use is made of parallel airflows 7 and 8. It is clear that in practice the inlet airflow 7 and the outlet airflow 8 are kept separate from each other.

30 According to the embodiments of Figures 3 and 4, the second channels 4 are directly branched off from the first channels 3, hence without a special connection conduit being used. In this case, this direct connection consists of a chamber 13 that is located immediately behind the plates of the plate heat exchanger 2, in which the first channels 3 discharge, as well as the

second channels **4** begin. The second airflow **8** is immediately bend back from the first airflow **7**, as is indicated with the numeral **14**.

Figure 3 also shows that the above mentioned means to generate the airflows **7** and **8** may consist of ventilators **15** and **16**, in which the ventilator **15** provides for the inward suction of the overall airflow, while the ventilator **16** provides for the extraction of the airflow **8** from the first airflow **7**.

Provided the device **1** is properly dimensioned, one ventilator **17** is sufficient, which, as depicted in Figure 4, pushes the air for the airflows **7** and **8** through the device **1**.

According to Figure 5, the second airflow **8** is branched off from the first channels **4** by means of at least two branches, in this case several branches **14A** that are situated on different locations according to the direction of the flow in the first channels **3**. Hence, a second airflow **8** is obtained that is composed of different partial flows **8A**, such that the air that is branched off and that is still relatively dry, is better distributed in the second channels **4** and hence, may absorb moisture more optimally.

It is noted that the principle of Figure 5 is not necessarily limited to parallel channels **3** and **4**, but also can be applied in a device **1**, as is depicted schematically in Figure 6, in which channels **3-4** are applied which run crosswise.

In Figure 7 another variant is schematically shown, in which for the second airflow **8** use is made of at least two partial flows **8B** and **8C** that are preferably separated from each other, respectively a first partial flow **8B** that is branched off before or near the inlet of the first channels **3** and which effects a cooling effect in the first part **18** of the first channels **3**, and a second partial flow **8C**, which is branched off from the second part **19** of the first channels **3** and/or at the exit thereof and is used for creating a cooling effect in the second part **19** of the first channels **3**. Hence, the advantages of this specific embodiment, as mentioned in the introduction, are obtained.

It is noted that the partial flow **8C** in itself can also consist of several partial flows, similar to the partial flows **8A** in Figure 5.

Figure 8 schematically shows a special embodiment, in which – apart from said heat exchanger **2** - also a so-called mechanical cooling **20** with at least one compressor is used, preferably two or more compressors, respectively **21** and **22**, as well as a controller **23** that controls the mechanical cooling **20** as a function of external parameters, such as the air humidity. As mentioned in the introduction, this combined device **1**, i.e. the combination of a cooling by means of a heat exchanger **2** as described above, and a mechanical cooling **20**, allows to always search for the most optimal combination.

The two compressors **21-22** have a different nominal power. Furthermore, the controller **23** comprises also a control to adjust the power of the compressors, preferably in a stepless manner, for example by means of a frequency controller.

Hence, it is achieved that exclusively the smallest compressor **21** is put into operation when only a small mechanical cooling is needed. At a higher desired power, exclusively the larger compressor **22** is put into operation. When a still higher power is needed, both compressors **21** and **22** are put into operation in a parallel manner.

For the stepless control, use can be made of a frequency controller.

The mechanical cooling **20** or compression cooling can be obtained with different kinds of compressors **21-22**, both piston compressors as well as screw compressors.

Figures 9 to 14 concern a special detail that can be implemented in the device **1**, such that another remarkable improvement can be realized when a moisture-absorbing and/or hygroscopic layer **10** is applied. This improvement consists in the fact that locally in this layer **10** additional means **24** are provided that promote the dispersion of the moisture in said layer **10**.

These means **24** are preferably embodied in such a way that they provide for a buffer action, i.e., they more or less collect and/or slow down the moisture that runs down the layer **10**, and hence promote a better dispersion by absorption.

According to Figures 9 and 10 these means **24** consist of in essence horizontal ledges **25** that cooperate with said walls **6**, more in particular said layer **10**, more in particular that are

attached thereto. Hence, the flow of moisture 26, more in particular the water that is running down through the layer 10, is more or less slowed down and an amount of liquid 27 is collected on the ledges 25, an amount which is redispersed by absorption. The excess liquid flows over the edge of the respective ledge 25 to the next ledge and also penetrates partially behind the ledge 25 through the layer 10 downwards. In this way dry spots are formed in the layer 10.

Figures 11 and 12 show a variant, in which the ledges 25 are provided with oblique passages 28. In these, droplets 29 are retained, such that a uniform dispersion is also promoted. The water droplets 29 also form a horizontal conduction for the airflow 8.

Figure 13 shows an embodiment in which the ledges 25 extend over the full width of the channels 4, however in which passages 30 in these ledges 25 have been formed.

However, as depicted in Figure 14, it is not excluded to implement the ledges 25 as completely closed, such that on each ledge 25 an amount of liquid 27 can be collected that subsequently may penetrate further downwards through the layer 10. Hence, at each level where there is a ledge 25 present, a redistribution of the liquid is foreseen over the total length of the second channels 4.

The present invention is by no means delimited to the embodiments as described in the examples and as shown in the figures, however, such method and device may be implemented according to different variants without going beyond the scope of the invention.

Claims

1. Method for cooling air, characterized in that this cooling is at least realized by directing the air to cool through first channels (3) of a heat exchanger (2), while in
5 second channels (4) of this heat exchanger (2) an evaporation is realized by wetting the walls (6) of these second channels (4) and in combination therewith directing an airflow (8) through the second channels (8).
2. Method according to claim 1, characterized in that at least part of the second airflow
10 (8) is cooled before bringing this airflow into the second channels (4).
3. Method according to claim 2, characterized in that the second airflow (8) is cooled by branching off this flow from the first airflow (7).
- 15 4. Method according to claim 2, characterized in that the second airflow (8) consists of two or more partial flows (8A) that are supplied to the second channels (4) at different locations.
5. Method according to claim 4, characterized in that the partial flows (8A) are branched
20 off from the first airflow (7) at different locations, such that at least one location is situated between the inlet and outlet of the first channels (3).
6. Method according to claim 5, characterized in that the partial flows (8A) are systematically branched off from the first channels (3) at different consecutive
25 locations.
7. Method according to any one of the preceding claims, characterized in that the second airflow (8) is oriented in essence parallel to the first airflow (7) in counter current.
- 30 8. Method according to any one of the preceding claims, characterized in that for the second airflow (8) use is made of at least two partial flows (8B - 8C) that are preferably separated from each other, respectively a first partial flow (8B) that is branched off before or near the inlet of the first channels (3) and which effects a cooling effect in the first part (18) of the first channels (3), and a second partial flow

(8C), which in itself can also consist of several partial flows (8A), such that this second partial flow (8C) is branched off from the second part (19) of the first channels (3) and/or at the exit thereof and is used for creating a cooling effect in the second part (19) of the first channels (3).

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9. Method according to any one of the preceding claims, characterized in that it is implemented in a plate heat exchanger (2) and at least part of the second airflow (8) from the first airflow (7) is branched off via direct connections between the compartments (11-12) that are formed between the plates, and this by means of passages in the plates and/or a mutual space or chamber (13) locally at the edge of the plates that are overlooked by both compartments (11-12).

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10. Method according to any one of the preceding claims, characterized in that said cooling is combined with a so-called mechanical cooling or compression cooling (20).

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11. Method according to claim 10, characterized in that the compression cooling (20) is controlled as a function of external parameters.

12. Method according to claim 11, characterized in that the compression cooling (20) is switch on to a larger extent as the humidity of the inlet air increases.

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13. Method according to any one of the claims 10 to 12, characterized in that use is made of several compressors (21-22), preferably with a different nominal power, such that one or more of these compressors (21-22) can be respectively switched on or switched off, as a larger or smaller compression cooling (20) is desired.

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14. Method according to any one of the claims 10 to 13, characterized in that use is made of compressors (21-22) with an adjustable power, preferably by means of a frequency controller.

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15. Device for cooling air, for the embodiment of the method according to any one of the preceding claims, characterized in that it consists at least of a heat exchanger (2) with first channels (3) for the air to cool and second channels (4) ; means (5) to wet the

walls (6) of the second channels (4) ; and means to direct the air to cool through the first channels (1), as well as to direct an airflow (8) through the second channels (4).

16. Device according to claim 15, applying the method according to any one of the claims
5 4 to 6, characterized in that the airflow (8) in the second channels (4) is branched off from the first channels (3) by means of at least two branches that are situated on different locations according to the direction of the flow in the first channels (3).

17. Device according to claim 15, applying the method according to claims 9,
10 characterized in that the heat exchanger (2) consists of a plate heat exchanger in which the second channels (4) run at least partially in counter-current relative to the first channels (3) and in which these second channels (4) are directly connected to the first channels (3) with the aim to branch off the second airflow (8) from the first airflow (7).

18. Device according to claim 17, characterized in that the direct connection at least
15 consists of a chamber (13) that is located immediately behind the plates of the plate heat exchanger (2), in which the first channels (3) discharge, as well as the second channels (4) begin.

19. Device according to any one of claims 15 to 18, characterized in that the heat
20 exchanger (2) consists of a plate heat exchanger in which the walls (6) of the second channels (4) are provided with a moisture-absorbing and/or hygroscopic layer (10) and that locally in this layer (10) additional means (24) are provided that promote the
25 dispersion of the moisture in said layer (10).

20. Device according to claim 19, characterized in that these means (24) consist of buffers or the like, formed by one or more of the following elements :

- one or more in essence horizontal ledges (25) that cooperate with said walls (6);
- 30 – one or more in essence horizontal ledges (25) that cooperate with said walls (6) and that are provided with passages (28-30) ;
- one or more in essence horizontal ledges (25) that extend over the full width, i.e. between two walls (6) of the second channels (4).

21. Device according to any one of claims 15 to 20, characterized in that it contains, besides said heat exchanger (2) also a so-called mechanical cooling (20) with at least one compressor (21-22), as well as a controller (23) that controls at least the mechanical cooling (20) as a function of external parameters, such as the air humidity.

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22. Device according to claim 21, characterized in that the mechanical cooling (20) contains at least two compressors (21-22) with a different nominal power, as well as a controller (23) to switch on these compressors (21-22) as a function of the need thereof, as well as to change the power thereof.

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Figures

Figures 1 to 14 : are identical to publication. No translation is provided.